27' 45" 30" 15" 26' 50" 1.2 0 0 0 0 0 CHESAPEAKE BAY EARTH SCIENCE ATLAS NO. 5 MAP 5-1 SAMPLING LOCATIONS UNITED STATES — EAST COAST MARYLAND CHESAPEAKE BAY PATUXENT RIVER AND VICINITY ROBERT H. CUTHBERTSON AND JEFFREY P. HALKA Mercator Projection Scale 1:40,000 at Lat. 38° 24' North American 1927 Datum SULFUR CONTENT LAMERE HENNESSEE AND JEFFREY P. HALKA ROBINSON NECK 1982 STATE OF MARYLAND DEPARTMENT OF NATURAL RESOURCES MARYLAND GEOLOGICAL SURVEY KENNETH N. WEAVER, Director EXPLANATION SAMPLE LOCATION SULFUR VALUE % DRY WEIGHT CONTOUR INTERVAL 0.3% CHESAPEAKE BAY EARTH SCIENCE ATLAS NO. 5 Chesapeake Bay Earth Science Atlas No. 5 represents the third in a series of map atlases depicting physical and chemical characteristics of the bottom sediments of Chesapeake Bay. These atlases are a product of a major research effort by the States of Maryland and Virginia in cooperation with the Chesapeake Bay Program of the Environmental Protection Agency to map the distribution of sediments, to identify the sites of deposition and erosion of such sediments, and to map the distribution of carbon and sulfur in the sediments. As shown in this Atlas, the western shore land areas bordering the Bay differ markedly from those of the eastern shore. A single tributary river, the Patuxent, drains the majority of the western shore land area and separates Calvert County to the north from St. Marys County. Excepting this river, streams emptying into the Bay are short and have small drainage basins. The eastern shore, in contrast, has a highly invaginated shoreline, extensively dissected by tidally flushed streams and contains many peninsular and island areas. In the field, location was determined by the use of Teledyne-Hastings Raydist navigational system. Accuracy of the system is ±0.5 meters. The sampling locations were pre-plotted, based on the grid design, and converted to the Raydist coordinate system. This coordinate system provided the basis for actual field locations. Nearshore, where the grid system was expanded to one kilometer by 300 meters, location was determined by shore based triangulation methods. the sediments and preventing anoxic conditions from developing. In contrast, the deep areas tend to be low energy environments in which fine-grained materials, including organics, accumulate. Anoxic conditions develop quickly in these materials because their fine-grained nature inhibits the passage of oxygen into the sediment from the overlying water. As sulfates are reduced to sulfides and combine with reactive metals, the sulfur is fixed and thus retained in the sediment in the same areas. A total of 691 sediment samples were collected and analyzed for textural parameters, as well as water, carbon, and sulfur content. The data are plotted on a series of overlays using the base map of the sample locations as reference. Along the shoreline of Calvert County, cliffs, which attain heights of over 100 feet, front the Bay. To the north of the Flag Ponds area these cliffs are composed of the variable muddy fine-grained fossiliferous sands of the Miocene Choptank Formation with shelly members predominating in two layers. These materials have accumulated in variable marginal marine to open shelf environments (Glaser, 1971). To the south of Flag Ponds, extending nearly to Drum Point at the mouth of the Patuxent River, the cliffs are composed of the unconformably overlying Miocene St. Marys Formation. Like the underlying Choptank Formation, the St. Marys Formation consists of a series of layers composed of variable amounts of sands, clays, and fossil materials. These materials are thought to have accumulated in restricted to open shallow marine environments (Glaser, 1971). Sulfur in this area of the Bay ranges from less than 0.5% in the coarser grained nearshore sediments to more than 1.5% in the finer grained, deeper water, anoxic sediments. Table 1 shows the values for sulfur as percent of dry sample weight determined for the various sediment size classes listed. The number of samples analyzed for each size class and the mean and range of sulfur values are also shown. The average mean %S value for all samples is 0.685% with a minimum of 0.020% and a maximum of 1.640%. Values shown in the table also reflect the increase in sulfur content with decreasing grain size. Sands have the lowest value of 0.208%, the finer silts 0.487%, and the finest clays have the highest average value of 1.079%. The Maryland Geological Survey and the Virginia Institute of Marine Sciences conducted companion programs in each of their respective states to provide detailed information about the sediments of the Bay. This research effort is the first attempt to provide such information on a Bay-wide basis. Past studies of the Bay sediments have been either very localized and site specific (Kofoed and Gorsline, 1966; Biggs, 1967; Palmer, 1972; Shideler, 1975) or recommaissance in nature (Ryan, 1953). SULFUR CONTENT Many chemical reactions occurring in the Chesapeake Bay estuary depend upon the availability of sulfur. In addition, the concentration of this element can serve as a pollution level indicator, aiding in the location of sites with the potential for high concentrations of heavy metals and other polluting substances. The Chesapeake Bay Earth Science Atlas No. 5 is published in partial In the anoxic environment occurring within most of the fine grained sediments of the Bay floor, sulfates are reduced to sulfides by anaerobic bacteria releasing energy for their use. The sulfides then combine with reactive metals such as iron and manganese, forming metal sulfides. These metal sulfides remain in the sediment where they are stable as long as the environment remains anoxic. However, if these sediments are disturbed and introduced to an oxidizing environment (e.g., through dredging), the following could occur: 1) the creation of an oxygen demand proportional to the concentration of organic carbon and reduced sulfur compounds in the sediments; 2) the formation of oxidation products analagous to those found in acid mine drainage, as a result of oxidation of iron sulfide phases;

3) the release of nutrients and trace metals into the environment. Thus, knowing the sulfur content of the sediments can play a role in identifying areas of anoxic sediments and estimating the potential for deleterious effects should these sediments be disturbed. No. R-805965, with the Environmental Protection Agency entitled Chesapeake Bay Earth Science Study, Sedimentology of Chesapeake Bay. Additional financial and logistical support was provided by the Capital Programs Administration, Energy Administration, and the Tidewater Administration of the Department of Natural Resources, State of Maryland. Fronting the cliffs at various locations along the Calvert County coastline, most notably at Flag Ponds, Cove Point, in the vicinity of Drum Point, and along the outer shoreline south of the Patuxent River, is a thin sheet of sediments collectively termed the Lowland Deposits. These are heterogeneous in composition consisting of admixtures of sands, muds, and subordinate gravels (Glaser, 1971). They are largely fluvial deposits and alluvium of the lower stream valleys and recent spit platform deposits accumulating through the processes of longshore drift. Table 1. Percent Sulfur measured in the different sediment size classifications. The success of such a scientific endeavor could not have been accomplished without the dedicated, professional services of the geologists and staff of the entire Maryland Geological Survey, and without the superb and encouraging leadership of Dr. Kemneth N. Weaver and Dr. Emery T. Cleaves. We also extend our gratitude and appreciation to the many people whose invaluable comments and suggestions helped initiate this project and contributed to completion of this Atlas. A very special thanks go out to the draftsperson whose excellent work has provided a clear and legible product, W. Morgan Woodward. The low lying lands of the Eastern Shore have an extensive network of bifurcating and meandering water pathways shallowly incised into the uncerlying Kent Island Formation. This deposit is composed of massive to thinly laminated silt-clay with minor sand bodies. The Kent Island Formation is thought to have accumulated in an estuarine environment, similar to today's Bay, during the Pleistocene (Owens and Denny, 1979). In conjunction with the continued rise in sea level in this area, numerous marshes overlie and fringe this formation and small pocket beaches have developed where sufficient quantities of sand exist. 0.940-1.480 Sulfur analysis was done on approximately one out of every four samples collected from the deeper waters of the Bay. Samples from shallower depths generally contain amounts of sulfur below the detection level of the analytical equipment and, thus, sample analysis was not performed. In general, the sand samples (i.e. samples with less than 25% water) were not analyzed for sulfur. Sulfur content was determined for 98 sediment samples using a Leco Induction Furnace (Model #521-000) and a Leco Automatic Titrator (Model #532-000). Contour lines shown were interpolated between analyzed stations on the basis of the Sediment Distribution (Map 5-2). Physiographic and Geologic Setting The Chesapeake Bay is located in the Embayed Section of the Atlantic Coastal Plain Province. The Bay is an estuary formed by the post Wisconsin sea level rise which drowned the lower valley of the Susquehama River. Prior to submergence, the Susquehama River had developed an extensive drainage network in unconsolidated to weakly consolidated sediments of Cretaceous, Tertiary, and Quaternary age. The sedimentary units become progressively younger southward along the Bay axis from the Cretaceous Potomac Group in the Upper Bay to the Quaternary sediments along the Lower Eastern Shore. SAND-SILT-CLAY 0.200-1.070 0.760 SAMPLING LOCATIONS REFERENCES The design plan for collection of bottom sediments is based on a uniform grid for systematic Bay-wide sampling. The grid concept of sampling offers a more efficient strategy for spatial correlation than most other sampling systems (McCammon, 1975). The grid is based on the Universal Tranverse Mercator Projection with one kilometer grid lines extended from a known point at 76°00W, 38°00N. Where the grid projection lines intersect the mean high water line along the Bay shoreline, the grid system was expanded to one kilometer (shore parallel) by 300 meters (shore normal) to a water depth of 3 meters. Biggs, R., 1967, The sediments of Chesapeake Bay: in G.H. Lauff, ed., Estuaries: Amer. Assoc. Advancement of Sci., p. 239-260. Glaser, J.D., 1971, Geology and mineral resources of Southern Maryland: Maryland Geol. Survey, Rept. of Invest. no. 15, 85 pp. Areas of high sulfur content tend to correspond to areas of deep water and fine-grained sediment. The nearshore and beach areas are high energy, wave dominated zones in which constant reworking of the sediments results in the removal of the finer-grained materials including the organics. In addition, high energy conditions stir up the bottom, aerating Kofoed, J.W. and D.S. Gorsline, 1966, Sediments of the Choptank River, Maryland: Southeastern Geol., vol. 7, p. 65-82. McCammon, R.M., 1975, On the efficiency of systematic point-sampling in mapping facies: Jour. of Sed. Petrol., vol. 45, p. 217-229. Owens, J. and C. Denny, 1979, Upper Genozoic deposits of the Central Delmarva Peninsula, Maryland and Delaware: U.S. Geol. Sur. Prof. paper 1067-A, 27 pp. Ryan, J.D., 1953, Sediments of Chesapeake Bay: Maryland Geology, Mines and Water Resources, Bull. 12, 117 pp. Shideler, G., 1975, Physical parameter distribution patterns in bottom sediments of the lower Chesapeake Bay estuary, Virginia: Jour. of Sed. Petrol., vol. 45, p. 728-737. FUNDING PROVIDED BY THE U.S. ENVIRONMENTAL PROTECTION AGENCY, CHESAPEAKE BAY PROGRAM CONTRACT NO. R805965 AND DEPARTMENT OF NATURAL RESOURCES: CAPITAL PROGRAM ADMINISTRATION, ENERGY ADMINISTRATION, TIDEWATER ADMINISTRATION THROUGH THE OFFICE OF COASTAL ZONE MANAGEMENT, NOAA U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION HYDROGRAPHIC CHART 12264 27' 45" 30" 15" 26' 50"